N O T I C E

DETERMINATION OF OPTIMUM VOLTAGES

OF ION FOCUSING DEVICES USING COMPUTER TECHNIQUES

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for

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Abstract

Electric potentials for two-dimensional cross-sections of ion focusing devices used in a mass spectrometer are calculated via a series of computer programs designed to compute potentials between areas of fixed voltages. Ion trajectories within these devices may be determined by computer and a histogram obtained which plots ion density against ion position along a plate of the focusing device. For each lens system, a plate voltage may be changed, the electric potentials recalculated, and a new histogram calculated in order to determine if the new voltage configuration has increased the device's efficiency. This process may be repeated until the optimum voltage values have been found for maximum particle transmission in each focusing device.

I. Introduction

A sequence of computer programs has been written by Dan Anderson which are capable of determining electric potentials between regions of fixed voltages in two dimensions. These programs were modified by B. Eckstein and may now be applied to the ion sources and ion collector of a mass spectrometer. Once the potentials have been calculated, another computer program produces a histogram of ion density versus ion location at a plate within the focusing device. From this histogram, the percentage of ion beam transmitted may be found. By changing the plate voltages and obtaining a histogram for these voltages, the best set of plate voltage values can be determined for maximum ion transmission and focusing.

II. Ion Focusing Devices

Four different ion focusing devices were analyzed in this study, three of which were mass spectrometer ion sources and one of which was a mass spectrometer ion collector assembly. The first ion source was developed by A. J. Loveless and R. D. Russell and will henceforth be referred to as the Loveless ion source. Figure 1 is a graph of a two-dimensional cross-section of the Loveless ion source. The second ion source is shown in Figure 2 and was developed by the California Institute of Technology. Accordingly, it is called the Cal Tech source. The last ion source is the National Bureau of Standards, or NBS, ion source depicted in Figure 3. The histograms were most often produced for an ion of strontium, specifically ^{88}Sr.

The Loveless ion source was developed for maximum transmission of a Pb^+ ion beam (1). The lens system is only 2 cm in length and the total accelerating voltage is 5000 V. The Pb^+ ions have an energy of approximately 0.15 eV, with a corresponding velocity of magnitude of 4.58×10^4 cm/s; and the center filament is operated at 1750 K. The focus electrodes are at 4995 V and the collimating slits at zero volts. The source was studied to find the best operating voltages for emission of ^{88}Sr.

The Cal Tech ion source is a device that was partially studied last summer as part of an LPI undergraduate internship, when the electric potential was computed for a maximum voltage of 10.0 V. The first drawing out plate was at 8.5 V, the second at 3.0 V. The collimator was at 1.5 V and the exit slit at zero volts. This summer the intermediate voltages for V_{max} = 10.0 V were changed and plate voltages were also scaled to V_{max} = 7500 V. Again, ^{88}Sr was used in all histograms.

The NBS ion source is the device used in a mass spectrometer run by Dr. L. E. Nyquist in Building 31 at the NASA Johnson Space Center. One of the elements most commonly analyzed for isotopic ratios is ^{88}Sr (which is why ^{88}Sr is used in all histogram studies). The maximum voltage is 7500 V with an operating temperature of 1300 to 2000°C. The plate voltages were measured last summer while the mass spectrometer was in operation with a seven digit voltmeter and the values obtained were:

a.	Drawing out plate	7484 V
b.	First discriminator	7285 V
c.	Focus plates	6673 V
d.	Second discriminator	449 V
e.	Exit slit	0 V

This source was analyzed last summer for a version scaled to a maximum voltage of 1000 V, and plots of the equipotential contours and exit slit histograms were obtained. This summer the electric potentials were calculated for the working voltages and histograms of the individual plates obtained. The voltages were varied and the appropriate histogram examined to determine whether or not focusing was improved.

The ion collector assembly consists of a series of plates terminating in a photomultiplier tube and is the collecting device for the mass spectrometer used by Dr. Nyquist (see Figure 4). The collector was analyzed to determine whether or not a significant percentage of particles were lost before they reached the photomultiplier tube and, if so, how to pervent this loss.

III. Experimental Procedures

In order to analyze any focusing device, all dimensions of the lens system must first be found, either from blueprints of the device or by actual measurement. Next, one must choose which two-dimensional cross-section to study. For this project, the cross-section with the smallest apertures was chosen because of the more stringent focusing requirements. Then the two-dimensional cross-section is placed on graph paper as in Figures 1 through 4.

The computer programs used in calculating the electric potential and histograms are written so that every focusing device must have the dimensions of 100 x 100. Thus, once the device has been placed on graph paper, the X and Y coordinates must be changed from centimeters (or inches) to integer steps from 1 to 100 (see Figures 1 - 4). From this 100 x 100 array, a boundary conditions file may be created that contains the locations of each plate voltage and the value of that voltage. File 1 is an example of one Loveless ion source. The boundary conditions file is called NAME.BND, where NAME refers to the lens system being studied. The suffix BND remains the same no matter what device is being studied in order to indicate that this is a boundary conditions file.

The initial velocities of the ^{88}Sr ions must also be determined. Since the ions have an energy of approximately 0.10 eV, the magnitude of the velocity is 4.69 x 10^4 cm/s. Because the ions may be emitted at any angle with respect to the filament, the computer calculates ion trajectories from 0 to 180 degrees in 15 degree steps relative to the filament. These X and Y velocities are contained in a file called MASS2.VEL (see File 2). Thus, 13 trajectories may be computed at any location on the filament. For the ion collector, the

angular dispersion of the ^{88}Sr beam is one degree, so trajectories are computed for 89.0 to 9..0 degrees in 0.2 degree steps at every location from which ions originated. The ions have been accelerated through 7500 V and now have a velocity of 4.06 x 10^5 cm/s.

Once the boundary conditions file NAME.BND has been created, the intermediate electric potential of the device may be calculated by means of two programs called BNDSET and ELECT. These programs are located in Room 180 of Building 31 at the Johnson Space Center on the hard disk numbered RK-29 and are designed to run on the building's PDP 11/40 computer located in the same room.

The program BNDSET creates two new files, NAME.RAN, an array file, and NAME.BIT, a bitmap file, from the boundary conditions file. (The user may call the array and bitmap files anything she or he desires, but retaining the boundary conditions file prefix and changing only the suffix reduces confusion.) The suffixes RAN and BIT always refer to an array file and a bitmap file, respectively. The bitmap contains the location and value of the boundary conditions. The array file ultimately will contain the value of the potential at each point in the 100 x 100 grid of the device.

The program BNDSET will also ask if the array file is new or old. If one has never calculated the electric potentials for a device of this geometry, the response is "N" for new. The computer then initializes each point in the array file to zero. If one has a.ready computed the electric potentials for a device of this geometry and now desires the electric potentials when a few of the plate voltages are changaed, one answers "O" for old. Then the computer will correct the old data for the new boundary voltages without having to

recalculate the entire array, and run time is shortened. When the program has finished, the computer prints a dot. BNDSET takes upwards of a minute to run. For an actual run of BNDSET, see Program 1.

The actual potential values are produced from the program called ELECT, which may only be started after BNDSET has been run for the current boundary conditions. ELECT asks for the array file and bitmap file names and asks whether the field is planar or radial (P or R). Since all focusing devices have rectangular apertures, the fields are planar. ELECT will also ask if one wants NAME.RAN printed. The usual response is "N" for no, as one's data consists of the histogram. Finally, ELECT will ask if the current limits of I = 2-99 and J = 2-99 are acceptable, which is answered by "Y" (i.e., yes). ELECT sets the perimeter potential at zero and calculates the potential for each point within the boundary.

The program ELECT uses a relaxation method to compute potential values. For each pass, the line printer writes (1) the number of times a pass has been made, (2) the X and Y coordinates of the potential being examined, (3) the new potential value at this location, and (4) the absolute value of the difference between the old potential value and the new. The program only stops calculating if one types Cntrl C, or if the difference between the old and new potential values is less than 0.001 volts. If one has typed Cntrl C and now wants to continue evaluation of the electric potentials so that they may be more accurately determined, one need only restart ELECT once more, and the program will take up where it left off. One need not run BNDSET again while the boundary conditions remain the same. Program 2 shows an actual run of ELECT.

If one is uncertain about the boundary conditions one has chosen and wants to be sure that the plates are at their proper locations, one may run a program called BMPNT and examine its line printer output. This output consists of a series of dots and X's, where the dots are points in the bitmap that have not been set at a voltage and the X's are the locations of the fixed voltages. BMPNT only requires the maximum value of IDIM and JDIM, i.e., 100, and the name of the bitmap file. This program is also on RK-29. A run of BMPNT is found in Program 3.

Once the electric potentials have been calculated for a lens system, one starts a program CONPL9 that (1) plots equipotential contours, (2) plots ion trajectories, and (3) computes a histogram of the Y-location of each particle when the X-coordinate reaches a certain value. This program may be found on disk RK-26 in room 180 of Building 31 at JSC. (Disk RK-26 also contains all boundary conditions, array, and bitmap files for each focusing device.)

Program CONPL9 will only run if a plotter is hooked up and is on. It first asks for the array file names (see Program 4). Then it asks "Contours or Trajectories." If one types "C," the computer ask the name of a batch input file. A batch input file is simply a list of the values of the equipotential contours to be plotted and is created using the editor. An example of a batch input file is found in File 3. All batch input files are located on disk RK-26. Once the contours have been plotted, the computer again asks "Contours or Trajectories." One may then type "C" and reference another batch input file, which will result in more contours being drawn on the plot; or one may type "T" so that ion trajectories may be calculated.

When trajectories are to be computed, the computer first asks for the bitmap corresponding to the array file already given. It then asks for the mass of the ions and a quantity called "cell size." This cell size is the length in centimeters that is covered by one unit of the 100 x 100 array in the X and Y directions and may be determined from the lens system graph (see Figures 1 - 4). Due to a hidden error in the logic of CONPL9, the mass must be entered as a negative number to produce accurate results.

The computer will next want to know whether or not trajectories are to be computed one at a time (Y or N). If the answer is Y, the computer will require the initial coordinates XO and YO and the initial velocities VXO and VYO. If the answer is N, the XO and YO values asked for are now starting values. At XO and YO, trajectories are computed for ions of any X and Y velocity by referencing a file such as MASS2.VEL when the computer asks for the initial conditions file. When all ion trajectories in MASS2.VEL have been computed at XO and YO, YO is increased by adding to it a quantity called AMT (which CONPL9 needs to be told), and trajectories are again computed from MASS2.VEL. This process is repeated until the Y-coordinate becomes greater than YUPPER (a quantity one must also tell the computer). Then the computer stops calculating trajectories. In this way, the computer will literally compute thousands of trajectories after being given only five parameters, i.e., XO, YO, YUPPER, AMT, and a velocity file.

CONPL9 also gives a choice of data output as data may go to the plotter and/or to the line printer. If data only goes to the plotter, the only output is a plot of each ion trajectory. If data goes to the printer, the computer needs additional parameters. First, it requires the change of X for which the

line printer outputs data. If one answers, for example, "65,85," the line printer will print the time, X- and Y-coordinates, and X- and Y-velocities for each step of the trajectory when the X-coordinate is between 65 and 85. If one answers "-1," none of the particle's positions are listed.

If data goes to the line printer and trajectories are computed from a velocity file, a histogram is produced once all the ions' paths have been calculated. The input "Range of Y for histogram" is the region in the Y dimension for which the histogram is computed. One usually chooses the Y-range to be symmetric about the center of the lens system. The next input is the value of X for which the histogram is computed. This X value is usually one array unit above the plate being studied so that one may determine the width of the ion beam along with percent transmission. The histogram itself is 252 units wide. The first and 252nd locations tell how many particles landed beyond the Y-range. The line printer prints the number of particles in each unit of the histogram and then gives a graph of the histogram. For an actual histogram, see Table 1.

Once a histogram has been obtained at a plate within the lens system, one can calculate the percentage of transmission of the ion beam. One may then change the voltage on this plate, recalculate the electric potential distribution, and, by obtaining another histogram, compare transmissions to see which is the better voltage. This process may be repeated until the optimum operating voltages have been determined.

IV. Results

A number of factors obstructed complete analyses of the four ion focusing devices currently under consideration. First and foremost was a lack of computer time. The set of programs used in this project only run on the PDP 11/40 located in Building 31, and this computer is greatly in demand, especially during the summer when special projects requiring computer time on this machine are being pursued by LPI interns and NASA personnel. Also, the PDP 11/40 is designed for running equipment and not for batch work and thus is not as fast as a computer specifically designed for these types of programs.

A third problem lay in the trajectory plotting program itself. Last summer the version used was called CONPL7. This program produced all the data that CONPL9 gives, but did not require the cell size. As a result, the initial velocities of the ions were arbitrarily scaled to the array without regard for the source's actual dimensions; and all histograms produced by CONPL7 last summer are wrong. (The CONPL? programs are derived from a program CONP20 written by Dan Anderson a few years previously and were an aim of this project, i.e., to produce a program capable of evaluating the focusing properties of a lens system.) Initially, CONPL7 was changed to a version called CONPL8, where CONPL8 included the array cell size. In CONPL8, however, it was discovered that the step size in the trajectory calculation was too large to produce an accurate histogram. Accordingly, the step size was reduced considerably (by a factor of 5) so that trajectories of 0.2% accuracy are obtained; and the new program was named CONPL9 for obvious reasons. Since CONPL9 takes much longer to calculate a trajectory, the velocity file was decreased from one containing 61 trajectories to one containing only 13 for the mass spectrometer sources.

Another delay in getting data results from the inconsistencies of the PDP 11/40. The program CONPL9 requires a line printer for the histogram, and the computer in Building 31 is the only 11/40 available with a line printer. Thus, when the computer went down, the project had to stop also, because almost all work is done by computer. (The histograms take very little time to analyze.) The only person capable of fixing the PDP 11/40 on short notice when it dies is Dan Anderson, who was on vacation for three weeks this summer. While he was gone, the PDP 11/40 passed away twice, and over a week of work time was lost.

However, a few results were obtained for the lens systems studied. For each source, a histogram at the plate whose voltage was being changed was used to determine the best plate voltage. However, as indicated by Figures 5 and 6, the criterion should have been the transmission through the exit slit, regardless of the plate being changed.

For each focusing device, a plot of the equipotential contours corresponding to the initial voltages was obtained. Then a few trajectories were plotted. Finally, the histograms were obtained for the different voltages (see Figures 5-8).

For the Loveless ion source, one can see from Figures 5 and 6 that, although 5000 V on the focusing electrodes gives 100% transmission through the electrodes, no ions pass through the exit slit. The data charts for each histogram are shown in Tables 2 and 3.

The Cal Tech source has hardly been analyzed at all but the data in Table 4 seems to indicate that the transmission through the first drawing out plate will be improved if the voltage is increased further.

The NBS ion source apparently requires the least improvement, although an exit slit histogram was not obtained for the new drawing out plate voltage of 7498 V (see Table 5). However, without changing the voltages on the first discriminating plate and focus plates, the entire beam transmitted by the drawing out plate is passed through the focus plates, i.e., 75.0% of the total ion beam is transmitted through the focus plates.

The ion collector assembly has been analyzed the least because of its efficiency, as it delivers 84.8% of the total ion beam to the conversion dynode of the photomultiplier tube. Since the collector assembly has a lower priority than the other focusing devices, it was not analyzed further.

At present, exit slit histograms are being computed for each of the three ion sources being studied. The data, however, has not yet been analyzed.

V. Further Possibilities

As one can tell by the (so far) sketchy results of this project, there is much more work to be done. First and most importantly, all four focusing devices must be completely analyzed by getting a histogram for the exit slit after the new electric potential distribution has been calculated.

The experimental procedure may be improved in a number of ways. One possible improvement is to put the programs onto different computer systems at JSC and LPI so that different lens systems may be analyzed simultaneously. Also, the user is no longer dependent upon the vagaries of the PDP 11/40. The project would also benefit if the programs were placed on faster computers, such as the Univac system in Building 12.

One may also want to determine whether or not it is possible to combine the three programs BNDSET, ELECT, and CONPL9 into a single program that will automatically change plate voltages until the best focusing conditions are obtained. A computer faster than the 11/40 would be a necessity, however, as the combined programs would take weeks to run otherwise.

Another variation of an ion source that has yet to be analyzed is one that uses a V-shaped filament. The first draft of the commands necessary to change CONPL9 so that a V-shaped filament may be analyzed was written this summer but was never tested.

The ion collector assembly should also be analyzed for the electron trajectories from the conversion dynode of the photomultiplier tube.

Any of these ion sources may also be analyzed in three dimensions from programs written by Dan Anderson. These programs were not used this summer because their run time is longer.

Finally, one may experiment with entirely new lens systems that have different geometries from any focusing devices currently in use.

VI. Conclusions

The data for each of the four focusing devices is obviously incomplete and can be improved if the computer time is available. One interesting result is that exit slit transmission is not necessarily improved by increasing individual plate transmission. Thus, one should always look at the exit slit histogram instead of the histogram for the plate whose voltage is being changed, otherwise, the data may be misleading.

VII. Acknowledgements

I would like to thank Dan Anderson for his patience and helpfulness in teaching me how to run the PDP 11/40 computer and his programs, as well as for the use of the programs themselves.

LIST OF FIGURES

LIST OF PROGRAMS*

Program 1. Teletype printout for a run of BNDSET for version KMQUT7 of the
Loveless ion source.

Program 2. Teletype printout for a run of   .CT for version KMQUT7 of the
Loveless ion source. Calculations of electric potential has already
been completed, so the voltage difference at the end of the first
pass is less than 0.001 volts. Line printer output has been
assigned to the teletype.

Program 3. Teletype printout for a run of BMPNT for the Loveless ion source
for version KMQUT7. (Any version of the Loveless source will give
the same output.)

Program 4. Teletype printout for a run of CONPL9 for version KMQUT7 of the
Loveless ion source. A plot of contours and trajectories as well
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* All underlined sections are typed in by the user.

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Table 3.   Histogram data chart for first collimator of Loveles ion source.

Table 4.   Histogram data chart for first drawing out plate of Cal Tech ion source.

Table 5.   Histogram data chart for drawing out plate of NBS ion source.

LIST OF FILES

File 1.   Boundary conditions file for Loveless ion source called KMQUT7.BND

File 2.   Velocity file MASS2.VEL for ^{88}Sr ions emitted from 0 to 180 degrees with respect to the filament, in 15 degree steps.

File 3.   Batch input file KMQUT7.BAT giving plate voltages of Loveless source called KMQUT7.

REFERENCES

1. Loveless, A.J. and Russell, R.D. (1969) Int. J. Mass Spectrom. Ion. Phys.
    3, 257-266.

Centimeters

5000V

Filament + Shield 5000V

Focussing and Deflecting
Electrodes

4995V

FIRST COLLIMATING SLIT
ØV

Second Collimating Slit
ØV
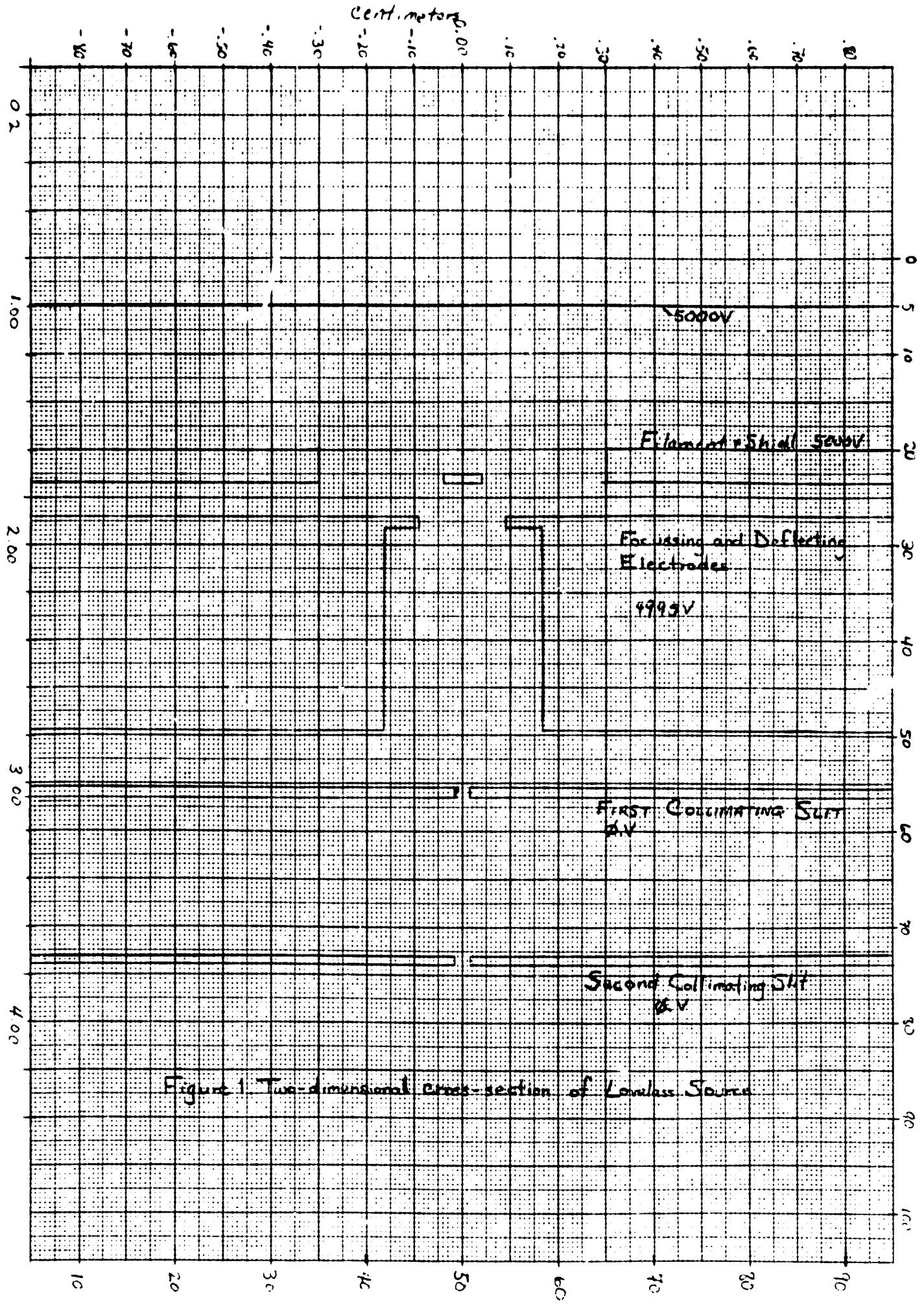
Figure 1 Two-dimensional cross-section of Lovelass Source
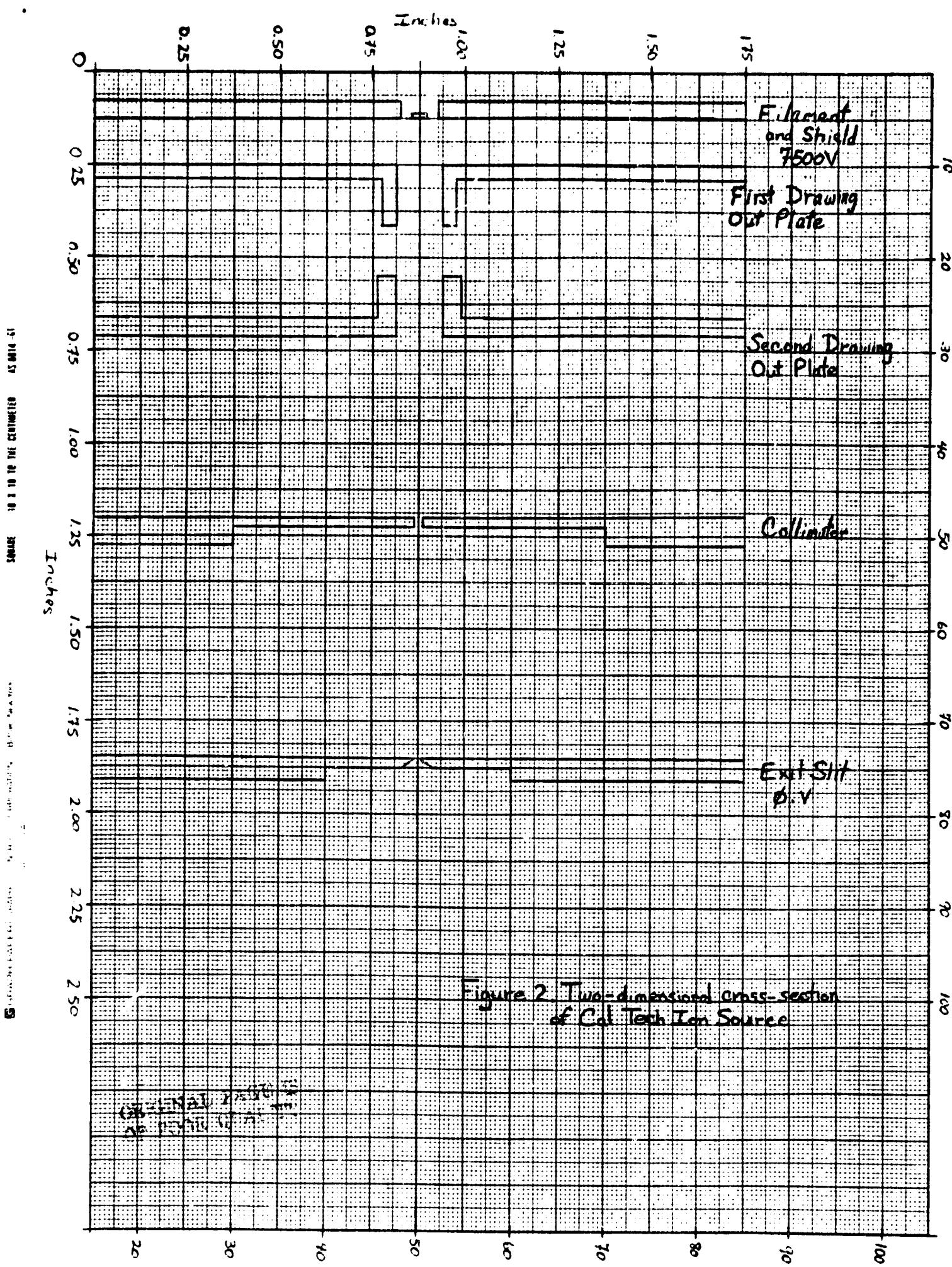
Figure 2. Two-dimensional cross-section of Cal Tech Ion Source

Filament Block 7500V

Filament + Shield 7500V

Drawing Out Plate 7484V

First Discriminating Plate 7285V

Focus Plates 6673V

Second Discriminator 449V

Exit Slit 0V

Figure 3. Two-dimensional cross-section of NBS Source

Current meters

-001

øV
Knife edge

-.017   øV

-.019 (Split)   -1500V

-.018   øV

-.013   -1500V
Multiplier
Front Plate

-1500V
Conversion Dynode

-1400V
1ST Dynode

-1300V
Second Dynode

-1200V

Third
Dynode

Figure 4.

Collector

Ion Multiplier Assembly
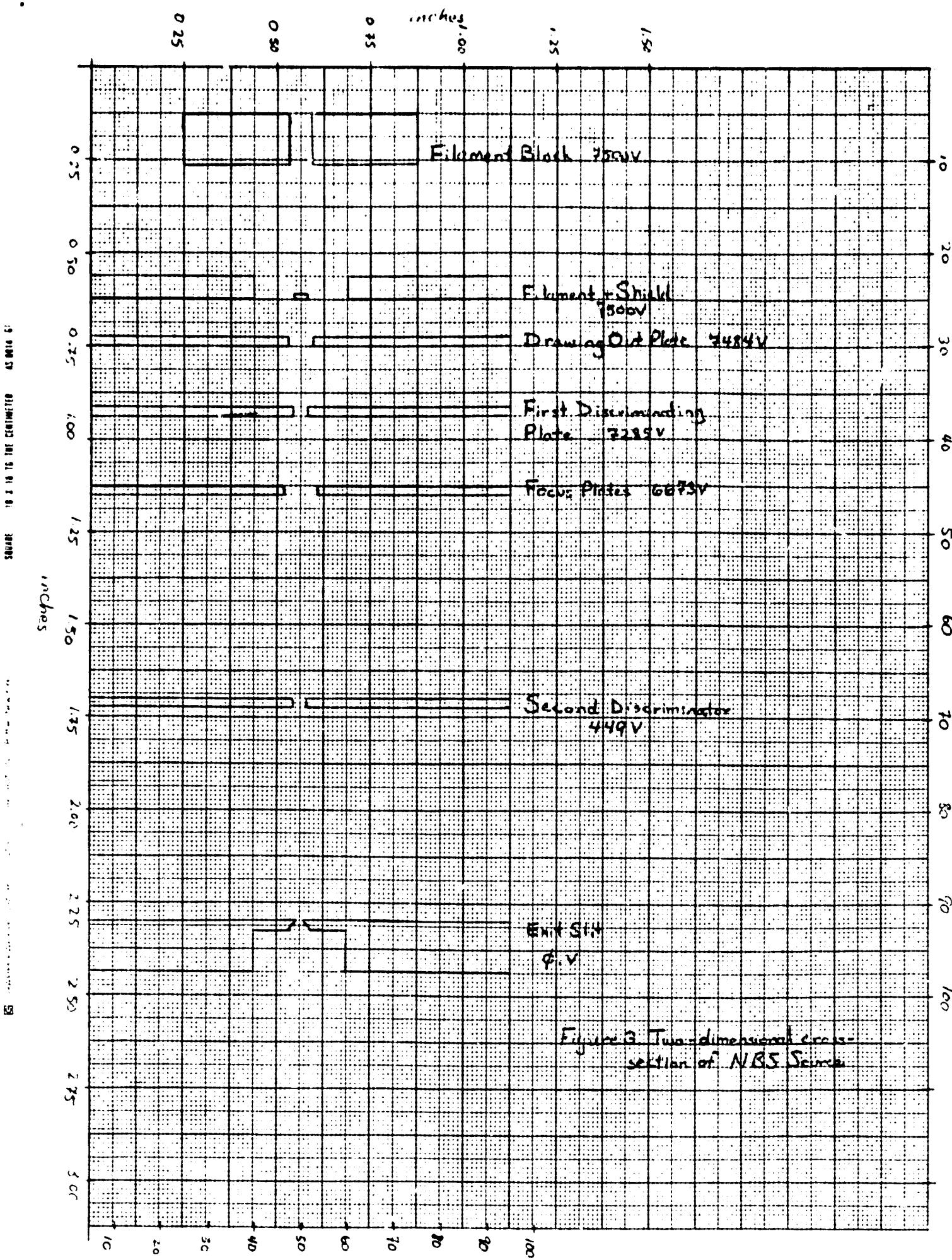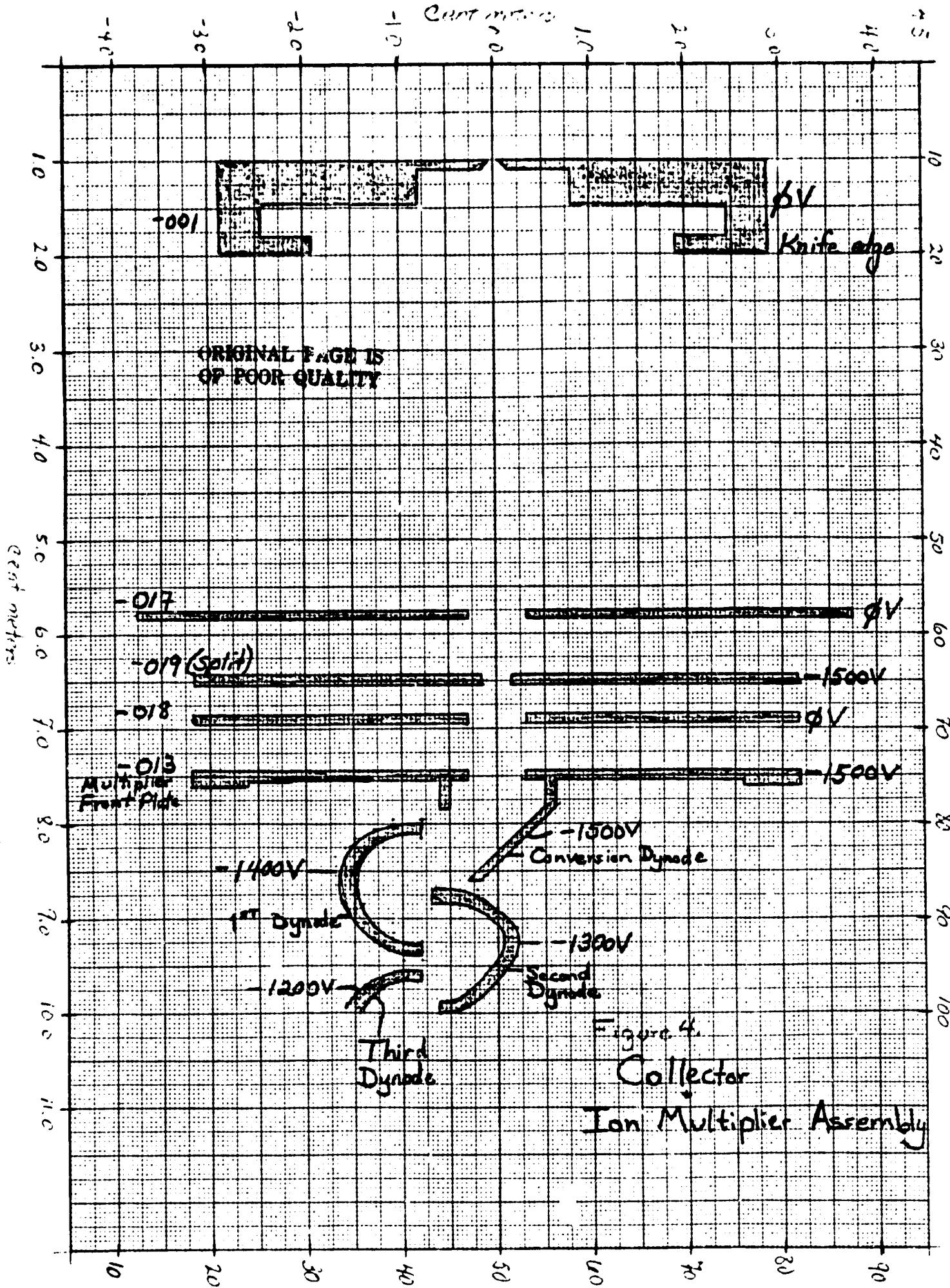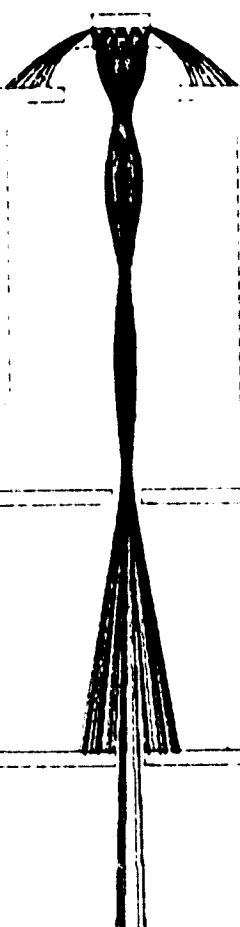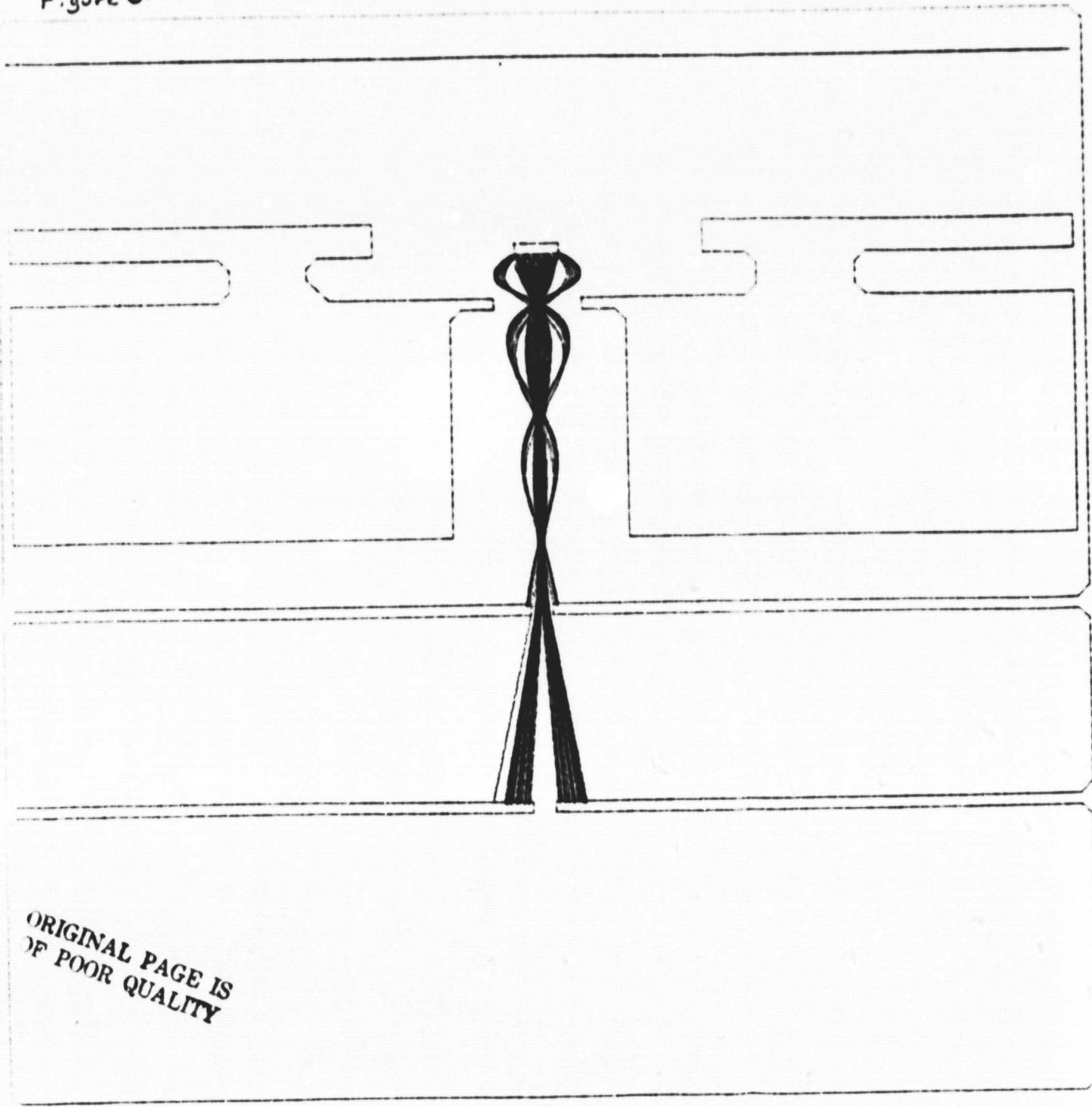
Figure 5.
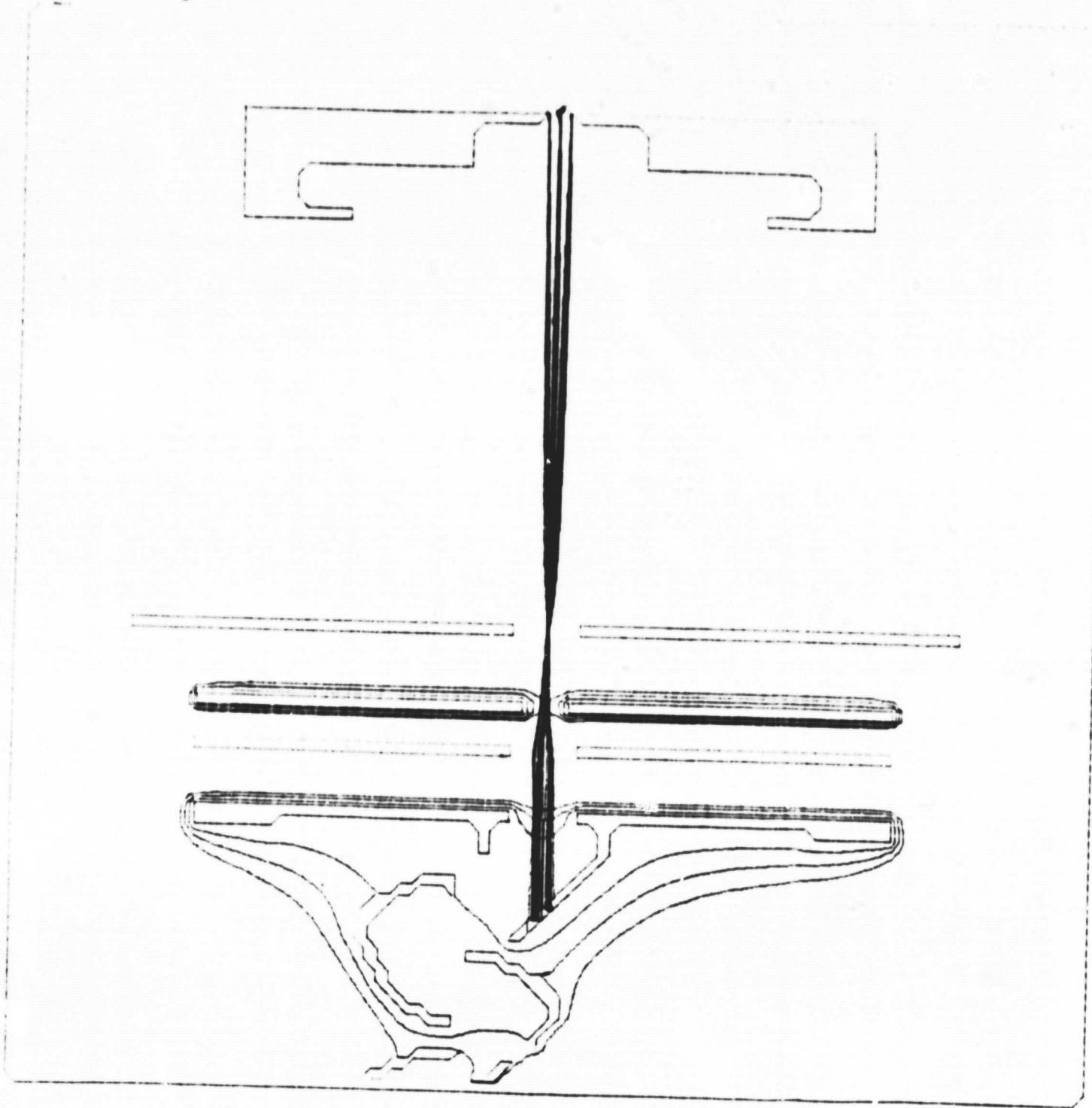
Figure 6.

Figure 7.

Figure 8.
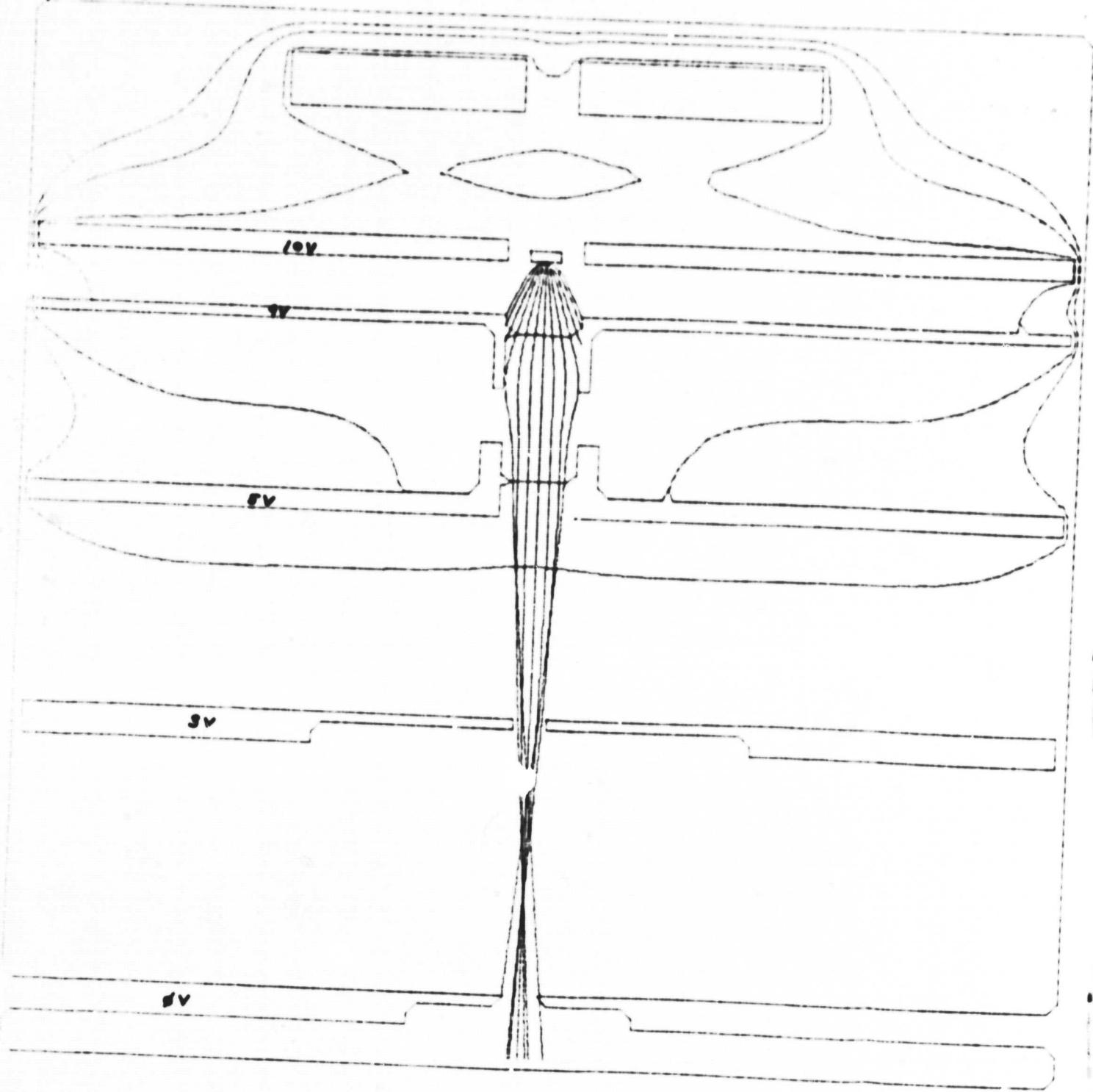
PROGRAM 1.

```
.R BNDSET
FILENAME OF ARRAY *DK1:KMQUT7.RAN
NEW OR OLD? O
NAME OF BITMAP FILE (OUTPUT) *DK1:KMQUT7.BIT
INPUT FILE NAME *DK1:KMQUT7.BND
.
```

PROGRAM 2.

```
.R ELECT

NAME OF ARRAY FILE *DK1:KMQUT7.RAN

NAME OF BITMAP FILE *DK1:KMQUT7.BIT

BOUNDARY CONDITIONS READ IN.

PLANAR OR RADIAL FIELD (P OR R): P

PRINT ARRAY NOW? N

CURR. LIMITS: I=  2- 99, J=  2- 99, OK? Y

   1  64  43     423.76          0.97656E-03
PRINT ARRAY NOW? N
```

PROGRAM 3.

```
.R BMPNT

 ENTER IDIM,JDIM 100,100

 NAME OF BITMAP FILE *DK1:KMOUT7.BIT

 STOP --

   .
```

PROGRAM 4.

```
.RUN DK1:CONPL9

ARRAY FILE NAME *DK1:KMOUT7.RAN

CONTOURS OR TRAJECTORIES: C

BATCH INPUT FILE NAME *DK1:KMOUT7.PAT

CURR. LIMITS: I=  1-100, J=  1-100, OK? Y

CONTOURS OR TRAJECTORIES: T

NAME OF BITMAP FILE (INPUT) *DK1:KMOUT7.BIT

GIVE PARTICLE MASS(AMU), CELL SIZE (X,Y-DIM CM)):-87.9056,.04,.02

TRAJECTORIES COMPUTED ONE AT A TIME?(Y OR N):N

DATA TO PRINTER?(Y OR N): Y

DATA TO PLOTTER?(Y OR N): Y

RANGE OF X FOR WHICH LINE PRINTER OUTPUTS DATA:-1

RANGE OF Y FOR HISTOGRAM:45,55

VALUE OF X FOR HISTOGRAM:72

ENTER XO,YO:23,48

UPPER LIMIT OF YO:52

AMOUNT BY WHICH YO IS INCREMENTED:1

INITIAL CONDITIONS FILE NAME:*MASS2.VEL
```

Table 1   Aug. 21, 1980

```
*        HISTOGRAM VALUES        *
```

1	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
51	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	0.	0.	0.	0.	0.	0.	0.	0.	0.
91	0.	0.	0.	0?	1.	1.	1.	0.	0.
101	0.	0.	0.	1.	1.	0.	1.	0.	0.
111	0.	0.	0.	1.	1.	3.	3.	1.	0.
121	0.	1.	2.	2.	3.	3.	3.	2.	4.
131	2.	4.	2.	2.	4.	2.	3.	2.	1.	1.
141	0.	0.	0.	0.	0.	0.	1.	0.	0.
151	0.	1.	0.	0.	1.	1?	0.	0.	0.
161	0.	0.	0.	0.	0.	0.	0.	0.	1.
171	0.	0.	0.	0.	0.	0.	0.	0.	0.
181	0.	0.	0.	0.	0.	0.	0.	0.	0.
191	0.	0.	0.	0.	0.	0.	0.	0.	0.
201	0.	0.	0.	0.	0.	0.	0.	0.	0.
211	0.	0.	0.	0.	0.	0.	0.	0.	0.
221	0.	0.	0.	0.	0.	0.	0.	0.	0.
231	0.	0.	0.	0.	0.	0.	0.	0.	0.
241	0.	0.	0.	0.	0.	0.	0.	0.	0.
251	0.	0.							

HISTOGRAM for FIRST COLLIMATING SLIT of LOVELESS SOURCE using CONPL9

    Array file: KMQUT7.RAN

    Bitmap file: KMQUT7.BIT

    Mass, Cell Size: -87.9056, 0.04, 0.02

    Range of Y for histogram: 45, 55

    Value of X for histogram: 54

    X_0, Y_0: 23, 49

    YUPPER: 52

    AMT: 1

    Velocity file: MASS2.VEL

    IY (Aperture): 110, 141

Table 2: HISTOGRAM DATA CHART for FOCUSSING ELECTRODES of LOVELESS ION SOURCE for ^{88}Sr (mass = 87.9056 amu) using program COMPL9

Focussing Electrode Voltage →	4995V	4998V	4999V	5000V		
Boundary Cond File Name	KMOUT1.BND	KMOUT2.BND	KMOUT3.BND	KMOUT4.BND		
Array file	KMOUT1.RAN	KMOUT2.RAN	KMOUT3.RAN	KMOUT4.RAN	Plate	Voltage
B.t map file	KMOUT1.BIT	KMOUT2.BIT	KMOUT3.BIT	KMOUT4.BIT	Element	5000V
Date of run	7-Aug-80	11-Aug-80	12-Aug-80	17-Aug-80	Focus Electrode	*Variable*
X-Value	26	26	26	26	First Collimating Slit	Φ.V
IY(Aperture)	69,182	69,182	69,182	69,182	Second Collimating Slit	Φ.V
Velocity file	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL		
IY(min),IY(max) for IY≠0	38,212	60,190	72,179	89,161		
Width of nonzero IY	174	130	107	72		
Percent transmission	80.0	93.8	100.0	100.0		

Table 3: HISTOGRAM DATA CHART for FIRST COLLIMATOR of LOVELESS ION SOURCE for ^{88}Sr (mass = 87.9056 amu) using program CONPLQ

First Collimator Voltage →	φ.V	50V	150V	800V		
Boundary Cond File Name	KMOUT4.BUD	KMOUT5.BUD	KMOUT6.BUD	KMOUT7.BUD		
Array File	KMOUT4.RAN	KMOUT5.RAN	KMOUT6.RAN	KMOUT7.RAN		
B. traj file	KMOUT4.BIT	KMOUT5.BIT	KMOUT6.BIT	KMOUT7.BIT	Plate Voltage	
Date of Run	18-Aug-80	19-Aug-80	20-Aug-80	21-Aug-80	Filament 5000V	
X-Value	54	54	54	54	Focus Electrode 5000V	
IY(Aperture)	110,141	110,141	110,141	110,141	First Collimator *Variable*	
Velocity file	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL	slit	
IY(main) IY(max) for IY≠0	94,157	95,156	94,157	94,156	Ext Slit φ.V	
Width of nonzero IY	63	61	63	62		
Percent transmission	80.0	80.0	80.0	80.0		

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Table 4: HISTOGRAM DATA CHART for FIRST DRAWING OUT PLATE of CAL TECH
ION SOURCE for 88Sr (mass = 87.9056 amu) using program CONPL9

First Drawing Out Plate Voltage →	5925V	5925V	5930V	5990V	6100V	6500V	7000V		
Boundary Cond File Name	LARY.BND	LARY1.BND	LARY2.BND	LARY3.BND	LARY4.BND	LARY5.BND			
Array file	LARY.RAN	LARY1.RAN	LARY2.RAN	LARY3.RAN	LARY4.RAN	LARY5.RAN		Plate	Voltage
Bitmap file	LARY.BIT	LARY1.BIT	LARY2.BIT	LARY3.BIT	LARY4.BIT	LARY5.BIT		Filament	7500V
Date of Run	17-Aug-80	17-Aug-80	18-Aug-80	18-Aug-80	19-Aug-80	20-Aug-80		First Drawing Out Plate	*Variable*
X-Value	28	36	36	36	36	36	36		
IY(Aperture)	94,157	94,157	94,157	94,157	94,157	94,157		Second Drawing Out Plate	3750V
Velocity file	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL			
IY(min),IY(max) fo. IV≠0	96,155	96,163	86,163	87,162	88,160	93,162	82,163	Collimator	2250V
Width of	59	77	77	75	72	69	75	Exit Slit	ØV
Humidity IV									
Percent transmission	100.0	63.5	63.5	65.4	67.3	69.2	76.9		

DATA SHEET

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Table 5: Histogram Data Chart for Drawing Out Plate of NBS Ion Source for ⁸⁸Sr (mass = 87.9056 amu) using program CONPL9

Drawing Out Plate Voltage→	7484V	7490V	7495V	7496V	7498V	7499V
Boxcar Cond File Name	MASSP2.BND	MASSP3.BND	MASSP4.BND	MASSP5.BND	MASSP6.BND	MASSP7.BND
Array file	MASSP2.RAN	MASSP3.RAN	MASSP4.RAN	MASSP5.RAN	MASSP6.RAN	MASSP7.RAN
B. map file	MASSP2.BIT	MASSP3.BIT	MASSP4.BIT	MASSP5.BIT	MASSP6.BIT	MASSP7.BIT
Date of Run	7-Aug-80	7-Aug-80	12-Aug-80	12-Aug-80	17-Aug-80	17-Aug-80
X-Value	28	28	28	28	28	28
IY (Aperture)	96,155	96,155	96,155	96,155	96,155	96,155
Velocity fib	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL	MASS2.VEL
I Max/I Mean for IY≠0	24,233	25,233	26,232	27,232	29,232	28,237
Width of nonzero IY	209	208	206	205	203	209
Percent transmission	73.1	75.0	75.0	75.0	75.0	75.0

Plate Voltage

Element 7500V

Drawing Out Plate *Variable**

First Discriminating Plate 7285V

Focus Plate 6673V

Second Discriminator 4491V

Exit Slit Ø V

DATA SHEET

File 1.

```
5020.
    5    2   94
   20    2   35
   21    2   35
   22    2   35
   23    2   35
   20   65   99
   21   65   99
   22   65   99
   23   65   99
   22   48   52
   23   48   52
   27    2   46
   26    2   46
   29    2   42
   30    2   42
   31    2   42
   32    2   42
   33    2   42
   34    2   42
   35    2   42
   36    2   42
   37    2   42
   38    2   42
   39    2   42
   40    2   42
   41    2   42
   42    2   42
   43    2   42
   44    2   42
   45    2   42
   46    2   42
   47    2   42
   48    2   42
   49    2   42
   27   54   99
   28   54   99
   29   58   99
   30   58   99
   31   58   99
   32   58   99
   33   58   99
   34   58   99
   35   58   99
   36   58   99
   37   58   99
   38   58   99
   39   56   99
   40   58   99
   41   58   99
   42   58   99
   43   58   99
   44   58   99
   45   58   99
   46   58   99
   47   56   99
   48   58   99
   49   58   99

800.
   55    2   49
   56    2   49
   55   51   99
   56   51   99
```

0.

73	2	49
74	2	49
73	51	44
74	51	99

```
0,4.685E4
1.213E4,4.525E4
2.342E4,4.057E4
3.313E4,3.313E4
4.057E4,2.342E4
4.525E4,1.213E4
4.685E4,0
4.525E4,-1.213E4
4.057E4,-2.342E4
3.313E4,-3.313E4
2.342E4,-4.057E4
1.213E4,-4.525E4
0,-4.685E4
```

File 2.

5000
800
0

FILE 3.

FILE 3.